APPENDIX I - Other Models Tested for bluefish

The Bluefish Technical Committee evaluated several models for their appropriateness for assessing bluefish populations. The previous assessment used a surplus production model (ASPIC) which reviewers felt produced inadequate results as structured. The shortcomings of the survey data limited the model to the recreational CPUE series as the only index with adequate spatial coverage and size distribution. A re-examination of the model using this correct CPUE series did not resolve the problems of the previous assessment. The model solution remained unstable with slight changes in the starting values. The committee chose not to use the production model in the current bluefish assessment.

Overview of Modified Delury (Catch-Survey) Model

The modified Delury or catch-survey model estimates a catchability coefficient to convert observed relative abundance indices to absolute abundance and fishing mortality rates (Collie and Sissenwine 1983; Conser and Idoine 1992; Collie and Kruse 1998). The model requires annual indices of population size in numbers for two life history stages (i.e., recruit and fully-recruited) estimated by research surveys, total annual fishery landings and discards in numbers, information on the partial recruitment of recruit size fish to the fully-recruited life stage (to partition F), and an estimate of instantaneous natural mortality. Other data needed are mean weights for each life stage and the relative selectivity of each life stage to the survey gear.

The modified Delury model is based on the equation:

$$N_{0,y+1} = (N_{0,y} + R_{0,y} - C_y)\, e^{-M}$$

where $N_{0,y+1}$ = fully-recruited stock size at the beginning of the year

$N_{0,y}$ = fully-recruited stock size at the beginning of the previous year

$R_{0,y}$ = recruitment in the previous year

C_y = catch

M = natural mortality

The equation assumes that a recruit is any animal smaller than the minimum size vulnerable to the fishery at the beginning of the survey year, and that will be fully-recruited to the fishery by the end of the survey year.

The catchability coefficient, calculated as

$$n'_{y'} = q_n N_{0y} e^{\eta t}$$

and

$$r'_{y'} = q_r R_{0y} e^{\delta t}$$

where r'_y = observed research indices of recruit bluefish

n'_y = observed research indices of fully-recruited bluefish

q = catchability coefficient of the research survey gear

$e^{\eta t}$ = log normally distributed random variable that represents survey measurement errors for recruits

$e^{\delta t}$ = log normally distributed random variable that represents survey measurement errors for fully-recruited indices

relates survey indices of abundance to absolute stock sizes.

Total mortality, Z, is estimated as

$$Z_{R+N,y} = \log_e \left[\frac{N_{0y} + R_{0y}}{N_{0,y+1}} \right]$$

Fishing mortality is calculated by solving the following equation for F

$$F=Z_{R+N,y}-M$$

or by using a harvest rate method

$$U_y = (C_y + Di) / ((R_y + N_y) * EXP(-M_y *(T_f - T_s)))$$

and then calculate F from U by trial using

$$U=F*(1-EXP(-Z))/Z$$

where U = harvest rate

C = landings

D = discards

T_s = timing of survey

T_f = timing of catch.

Delury Data Inputs and Results

MRFSS

The MRFSS CPUE index from 1982-2003 was transformed using a negative binomial transformation for all trips that targeted bluefish and non-targeted catch, and was partitioned into an age-0 (recruit) and age-1+ (fully-recruited) index to provide a measure of encounters with bluefish where A+B1+B2 = total catch. The timing of the survey and catch during the year was 0.58, which corresponds to peak catches and landings of bluefish. Natural mortality was included as 0.20. The total removals, as coastwide landings (A+B1) and discards (15% of B2), were included along with individual weights for recruits and fully-recruited fish from the MRFSS survey and commercial and recreational removals. The bootstrapping option was set at 2000.

Results with MRFSS Data

While recruit and fully recruited indices correlated relatively well, fully recruited CPUE and catch correlated poorly. Estimates of *F* were unreasonable and produced some negative estimates over the time series. Catchability was extremely low and estimates of stock size were unreasonable with the age-0 and age-1+ stock sizes equal in some years.

NEFSC Bottom Trawl Survey

The NEFSC trawl survey from 1982-2003, calculated as a geometric mean, was partitioned into an age-0 (recruit) and age-1+ (fully recruited) index to provide a measure of encounters with bluefish. The timing of the survey was 0.75 and peak catch during the year was 0.58. All other parameters are the same as for the model runs using MRFSS data. Age-0 bluefish were split into two spring and summer cohorts, with each index paired with the fully recruited index for additional model runs.

Results with NEFSC Bottom Trawl Survey

There was weak correlation between the recruit and fully recruited indices; and indices and catch. Estimates of *F* were unreasonable and produced some negative estimates over the time series. Estimates of stock size and biomass appeared unreasonable with the age-0 and age-1+ stock sizes equal in some years. In all cases the model was not able to complete all 2000 bootstraps without error.

Modified Delury Conclusions

The Bluefish Technical Committee rejected the modified-Delury model for two main reasons. First, the model assumes that recruits are not exposed to *F* until they are fully recruited. The bluefish fishery cannot meet this assumption. Second, there are weak relationships between recruit and fully recruited indices; and between indices and catch. The weak relationships may potentially be due to *F* on recruits and weak adult index values. Most surveys are not designed to adequately sample adult bluefish.

ASPIC Model

The ASPIC program (version 5.05) was used to estimate population biomass and fishing mortality for the Atlantic coast bluefish stock. ASPIC is a non-equilibrium surplus production model that can fit several catch-effort or abundance data series and has been used in the past several bluefish stock assessments and serves as the basis for the current FMP. The results of an ASPIC model for bluefish were reviewed in SARC 39 (June 2004) and it was concluded that the model was unstable and the calibration data was inappropriate. The Technical Committee revised the fisheries-dependent and catch data series for a re-evaluation of the production model. The model was fit to the 1982 – 2004 time series of bluefish total catch from along Atlantic Coast.

ASPIC Model Calibration

Input Series

The data series used in the ASPIC model included a fishery-independent index of relative biomass and a fishery-dependent series of weight-based catch-per-unit-effort. Annual estimates of bluefish weight per tow calculated from the NEFSC fall inshore survey for the 1982 - 2004 time period provided the fishery-independent biomass index. The fishery-dependent series was generated from the MRFSS intercept and catch estimate data as described in Section 4.2.1. The re-transformed year estimates from the GLM model were used for the recreational CPUE index.

Output/Results

Parameter Estimates

The bluefish stock was modeled using 1982 as the start year. The population growth rate, *r*, was estimated at 0.20. Carrying capacity, *K*, was estimated at 4,341,000 mt. The value of maximum sustainable yield, MSY, was 219,300 mt and the corresponding biomass, B_{MSY}, was 2,170,000 mt based on the optimum model results. The fishing mortality associated with the maximum sustainable yield, F_{MSY}, was estimated to be 0.10. Fishing mortality in 2004 was estimated at a value of F_{2004}=0.12. In 2005, the starting year biomass was predicted as B_{2005}=110,900.

Goodness of Fit of Model Used

Prager et. al. (1996) provided indicators of potential reliability of the fitted model, based on measures of contrast within the data. One is a coverage index, which indicates how widely stock biomass has varied between 0 and *K*, the carrying capacity. The coverage index ranges from 0 (least reliable) to 2 (most reliable). The nearness index indicates how closely a modeled stock has approached the biomass level producing MSY. This index ranges from 0 (least reliable) to 1 (most reliable). The optimum fit of the bluefish biomass-dynamic model yielded a coverage index of 0.03 and a nearness value of 0.54.

Precision of Parameter Estimates

Bootstrap trials (500 times) were run to provide an indication of the bias associated with the parameter estimates. The bootstrap parameter estimates were then used to calculate 80% confidence intervals (Prager 1994). Bootstrap results indicate that model parameters were estimated moderately to poorly. For example, the bootstrap analysis suggests there is an 80% probability that MSY is between 17,170 and 484,400 mt. The value for F_{MSY} estimated by ASPIC has an 80% probability of lying between 0.049 and 0.14.

Summary of ASPIC Model

The working group felt the results of the ASPIC assessment were unreliable and not suitable to serve as the basis for management decisions. First, the ASPIC model assumed that the NEFSC autumn inshore bottom trawl survey index was representative of the available bluefish biomass, following methodology used in previous assessment work (Lazar and Gibson 2002; Lee 2003). As identified in the previous review, the NEFSC biomass index has been assumed to represent the average biomass for the respective years. The NEFSC length samples indicate that over 90% of the bluefish caught in the autumn inshore survey are less than 40-cm fork length, and therefore mostly age-0 and age-1 fish. Age samples from the commercial and recreational fisheries provide evidence that the ages observed in the fisheries are not limited to age-0 and age-1 fish (Boreman 1983; NEFSC 1994a, 1994b, 1997). As such, the NEFSC autumn inshore survey may be more suitable as a recruitment index than an index representative of the annual average fishable biomass (Boreman 1983; NEFSC 1994b). Additionally, there was a low correlation between the NEFSC index and recreational CPUE series (0.305).

There is also a lack of contrast in the catch and index data, as indicated by the low coverage index value. This points to poor information content in the data and contributes to higher imprecision of parameter estimates in the bootstrap analysis.

As a result of the problems encountered in the present iteration of the analysis, the Technical Committee dismissed the production model as the primary assessment model.